From the present position of varieties in commercial cultivation the detection of a race of crown rust (race number 259) capable of attacking "Victoria" has been disturbing. As previously indicated, this collection was first received from Queensland in 1951 on leaves on the variety "Vicland". In subsequent years the race has become more widely distributed in southern Queensland and has been prevalent on the north coast of New South Wales, occurring on varieties other than "Vicland". In November, 1954, "Vicland" was observed carrying appreciable crown rust at Parkes in the Central West of New South Wales. Invariably rust from "Vicland" has proved capable of attacking Victoria seedlings.

As Victoria blight has now been recorded in Queensland, and with the wider distribution of the "Victoria"-attacking crown rust race, this variety must be considered of doubtful value in oat breeding programmes.

TABLE 1.

Typical Reactions of Certain Races of P. coronata avenae *Expressed as Means of Rust Infections.*

New Physiologic Race No.	Mean of Reactions on New Differential Set of Varieties.										Old Physiologic Race No.
	Anthony.	Victoria.	Appler.	Bond.	Landhafer.	Santa Fe.	Ukraine.	Trispernia.	Bondvic.	Saia.	
203	4	1^n	4	4	;	;	4	1	1	;	45, 57
226	4	1^n	4	0;	;	;	4	1	1	;	1, 6
230	;	1^n	4	0;	;	;	4	1	1	;	20
237	4	1^n	4	0;	;	;	;	1	1	;	1, 6, 102[1]
238	;	1^n	4	0;	;	;	;	1	1	;	7, 40, 103 (or 46)
240	4	1^n	2	0;	;	;	;	1	1	;	9
259	4	3	4	0;	;	;	4	1	1	;	114
286[2]	4	1^n	3	0;	4	4	4	4	3	;	6

[1] Race 102 on Saia is noted as a 2 type reaction.

[2] Race first recorded in present investigations and number assigned by central authorities, Ames, Iowa, U.S.A.

Of extreme importance also was the culture maintained at Sydney University as B.C. 37. This was collected on leaves of the variety "Trispernia", late in the season in the spring of 1953, in the field at Castle Hill Research Station, near Sydney. Only occasional susceptible pustules were found on a few plants of this variety and the possibility of such plants being not true varietal types was considered. However, such pustules transferred to seedlings of "Trispernia" gave rise to complete susceptibility on every plant. Seedlings of "Landhafer", "Santa Fe" and "Mutica Ukraine" when tested were also found to be susceptible. The differential variety, "Bondvic", was also moderately susceptible, whereas two of the parents in its pedigree, "Bond" and "Victoria", showed characteristic resistant reactions. In this respect it resembles race 233 overseas. The reactions of this collection on the new differential set were submitted to Dr. M. D. Simons, Ames, Iowa, U.S.A., for race designation. He reported that this was the first record of this race in any part of the world, and assigned a new race number, 286, to it. In view of the importance of this race, careful observations were made in the field during the 1954 season especially on differential rows at Castle Hill, where crown rust infection reached epiphytotic proportions. Susceptible pustules were found late in the maturity of the plants on "Trispernia", "Landhafer", "Santa Fe" and "Ukraine". In addition "Bond", "Victoria" and "Ruakura" were also observed carrying fully susceptible pustules. "Ruakura" is resistant to the common race, race 6, on the former differential set. The identification of these 1954 isolates has not been completed owing to the high summer temperatures and the limited capacity of the light room. The characteristic resistant reactions of the important differential varieties in both the seedling and adult stages is indicated in Table 2. The effect of temperature on seedling reactions is also shown in this table.

The variety "Klein 69B" was included in the differential sets since it has a measure of resistance against most crown rust races in the field. In 1952 an isolate from susceptible adult plants of this variety was collected in the field at Dundas, in the Sydney metropolitan area, by Professor Waterhouse, and exhibited a fully susceptible seedling reaction, assessed a (3^+) type as a mean reaction. The characteristic seedling reaction given by isolates to which adult plant resistance is shown is a low mesothetic (X^-) type. On host reactions this collection was designated as race 237 on the new differential set or race 6 on the former. Amongst 1954 collections, however, a few cultures were observed conforming to race 237 which gave a mesothetic reaction on "Klein 69B". Hence, by use of the variety "Klein 69B", two biotypes of race 237 can be distinguished, one attacking this variety and another showing moderate seedling resistance. In field collections, the more common conforming to race 237 has been that giving the higher seedling reaction on "Klein". It has occurred frequently in mixtures with race 259 from southern Queensland on susceptible varieties other than those having "Victoria" as a source of crown rust resistance. Collections on "Victoria" and "Vicland" have invariably conformed to race 259 reactions.

TABLE 2.

Characteristic Resistant Seedling and Adult Plant Reactions of Certain Differential Oat Varieties to Certain Australian Races of Puccinia coronata avenae.

Variety.	Seedling Reaction.		Adult Plant Field Reaction.
	Low Temperature.	High Temperature.	
Trispernia	1^-	2^-	1^n [1]
Landhafer	;	1^-	Immune
Santa Fe	;	1^-	Immune
Victoria	1^{-n}	1^n–2^-	Immune
Ukraine	;	2^-	Immune
Bond	0;	0;	Immune
Ruakura	1^-	2^-	1

[1] Characterized by rapid teleutospore formation.

Most collections conforming to race 6 exhibit the lower mesothetic reaction on this variety, however, since race 6 on the former differential set constitutes by far a greater proportion of determinations than does race 237 on the new set.

No other races have as yet been separated into biotypes on "Klein" and isolates capable of attacking this variety are on the current differential set diagnosed as race 237 or on the former as race 6. It seems probable that mutation phenomena are responsible for the changes in pathogenicity observed in the fungus, and on this basis "Klein" may separate other races into additional biotypes, and it is therefore included in all sowings of differential varieties. The resistant mesothetic reaction is more difficult to read than other reactions, but is quite characteristic and with experience can be easily assessed. There is no evidence to indicate that the mesothetic type of reaction is influenced more by changes in environment than any type influenced, for instance, by temperature changes. The (X^-) type of mesothetic reaction at higher temperature was rated as an (X^+), but never as a (3) or (4) type.

The variety "Ukraine" gave reactions which are worthy of comment. It was initially observed that collections made from Castle Hill and other field centres on adult plants of susceptible varieties where "Ukraine" itself was resistant gave susceptible seedling reactions on this variety. Adult plants subsequently tested in the glasshouses with these collections showed resistance. It appears, therefore, that "Ukraine" has in its genotype a factor or factors conferring adult plant resistance. It was observed, however, that at the same time certain races, as indicated in Table 1, gave seedling resistance on

"Ukraine", characterized by a fleck reaction. Race 237, previously mentioned, is a case in point. Adult plant tests with the biotypes of race 237 attacking "Klein" in both seedling and adult plant stages exhibited, as expected, "Ukraine" resistance. Races 238 and 240, collected in low proportions, also exhibit a completely resistant seedling reaction on "Ukraine". The nature of the inheritance shown by the seedling and adult plant factors in "Ukraine" and their association is being investigated in appropriate genetical studies.

In view of the importance of "Bond" in the differential set, since it has been, and still remains, one of the most widely used sources of resistance in crown rust resistance breeding programmes, some observations on the behaviour of this variety are pertinent. The two races, 45 and 57, capable of attacking "Bond" were both recorded in 1949 (Waterhouse, 1952) from collections made in the central coast region. They have occurred sporadically since, race 45 being recorded from the central tablelands in 1950, but, apart from this instance, races capable of attacking "Bond" have been restricted to the central coast area near Sydney, until 1953, when two collections from other areas showed a mixture of races on "Bond". From the mixtures, race 57 was isolated, the collections being sent from Raymond Terrace and Coff's Harbour, thereby showing a wider distribution for this race. In 1954, adult plants of "Bond" were quite heavily infected towards the end of their growing season at Castle Hill, but the occurrence of "Bond"-attacking races in the field is sporadic and infrequent. In this connection it will be of considerable interest to follow the behaviour of the variety "Bovah", which has "Bond" in its parentage. The "screening" effect of "Bovah", if collections capable of attacking "Bond" appear in appreciable proportions, will be of particular importance.

TABLE 3.

Typical Reactions of Certain Physiologic Races of P. coronata avenae *Expressed as Means of Rust Infections.*

Old Physiologic Race No.	Mean of Reactions on Old Differential Set of Varieties.													New Physiologic Race No.
	Ruakura.	Green Russian.	Hawkeye.	Anthony.	Sunrise.	Victoria.	Green Mountain.	White Tartar.	Red Rustproof.	Sterisel.	Belar.	Bond.	Glabrota.	
1	4	4	4	4	4	1^n	4	4	4	4	4	0;	0;	226, 237
6	1	4	4	4	4	1^n	4	4	4	4	4	0;	0;	226, 237, 286
7	4	4	;	;	4	1^n	;	;	4	4	4	0;	0;	238
9	1	1	3	4	2	1^n	4	4	2	1	1	0;	0;	240
20[1]	4	4	4	;	4	1^n	;	;	4	4	4	0;	0;	230
40	4	4	;	;	4	1^n	4	;	4	4	4	0;	0;	238
45	4	4	4	3	4	1^n	3	3	4	4	4	4	0;	203
46 (or 103)[2]	4	2	;	;	4	1^n	;	;	4	4	4	0;	0;	238
57	1	4	4	4	4	1^n	4	4	4	4	4	4	0;	203
102	;	;	4	4	4	1^n	4	4	4	4	4	0;	0;	237
114[3]	1	4	4	4	4	3	4	4	4	4	4	0;	0;	259

[1] First Australian record.

[2] By the commonly accepted definition of resistant and susceptible reactions, race 103 first described by Waterhouse corresponds to race 46 first described by Murphy. Further explanation in text.

[3] Race first recorded in present investigations and race number assigned by central authorities, Ames, Iowa, U.S.A.

Race Identification on Former Differential Set.

Race identification was continued during 1953 and 1954 on the old as well as the new differential set of varieties. This was considered desirable to enable **a comparison** to be made of the range of pathogenicity exhibited on the two sets and to assess their relative merits to pathologists and plant breeders. The races identified on the former differential set from field collections since 1952 are shown in Table 3. In general they are rather similar to those described by Waterhouse (1952) for previous Australian races. Race 20 is a newly described race for Australia, being first described by Murphy at Iowa. It is characterized by a resistant reaction on "Anthony" and the two varieties of *A. sativa orientalis*, "Green Mountain" and "White Tartar". It also differs from the most prevalent race, race 6, in its susceptibility on "Ruakura". This collection was forwarded from Taree in New South Wales.

Races 3, 45, 47, 77 and 104 described by Waterhouse (1952) have not been identified during the past two seasons. Race 45 is included in Table 3, however, as it is maintained as a stock culture at Sydney University. Collections attacking "Victoria" have all conformed to one race, which differs from race 6 solely in its ability to attack this variety. The reactions on the former differential set show that it is a new race not described in the Iowa key and was formerly described as Sydney University B.C. 30, but, as indicated in Table 1, it conforms to race 259 under the new scheme. When the reactions were submitted to the authorities at Ames, Iowa, race number 114 was assigned to this race peculiar to Australia in race determination investigations. The reaction on "Victoria" is of a (3) type, but is clearly a susceptible one. Race 6 was again the most prevalent race, followed by races 1 and 114. Others comprised a small proportion of the determinations, but are important in revealing the variability in the crown rust organism.

Certain collections were found to conform to race 46 or 103. If the commonly accepted definitions of resistant and susceptible reaction types are adopted, then these two races are similar. Race 46 was first described by Murphy, and 103 subsequently by Waterhouse (1952). Differences in reaction types are recorded on certain varieties. For example, the reaction types on "Green Russian" are recorded as (0) and (2) respectively; other more minor differences are shown on other varieties. Aspects associated with minor variations in host plant reaction types owing to environmental modifications have already been discussed; on this basis it is perhaps better to consider the two races as corresponding to one another. This point is later referred to and discussed.

As found by Waterhouse (1952), a large proportion of collections have comprised more than one race, and as many as three races have been separated from one collection using the former differential set. With additional varieties from the new set these could be separated further. For example, one collection from wild oats submitted from Hermitage, Queensland, comprised a mixture of races 1, 6 and 7. It gave, in addition, a mixture of resistant and susceptible reactions on "Ukraine" which subsequently showed that race 6 could be further subdivided into two biotypes. On the new differential set the collection comprised a mixture of races 226 and 237. Mixtures of races 1 and 6 (distinguished by their reaction on "Ruakura") were common; the mixtures of races 237 and 259 recorded from Queensland particularly have been noted.

The mixture of races from the one collection appeared to indicate that there was no significant correlation between the amount of inoculum used and the amount of mixing revealed on the differential varieties. The presence of mixtures of races may have various implications. It may indicate the existence of a high mutation rate in the fungus or little competitive effect between races on a common susceptible host. The details of the groupings in mixtures will be presented when current season's surveys are complete. It is worthy of note, however, that mixing occurs on cultivated varieties and on species of wild oats.

Comparison of Race Identification on the Two Differential Sets.

It is apparent from an inspection of Tables 1 and 3 that all collections could have been adequately designated as to race number on the original set either from the key for identification of previously described races or with the new number supplied by the central authorities for the "Victoria"-attacking race. The former set, because it contains more varieties, and a greater number of genetic factors concerned with crown rust reaction, permits the expression of a greater range of variability in pathogenicity. In the present instance eleven races were described on the old set (ten occurring from field collections during the 1953–54 period) compared with eight on the new. However, a variety such as "Ruakura" is of no importance in a breeding programme, although it separates races 1 and 6. Similarly, contrasting reactions of resistance and susceptibility with certain races were observed on varieties such as "Hawkeye", "Anthony", "Sterisel", "Red Rustproof" and "Green Mountain", which are of little direct economic importance or as sources of crown rust resistance. The reactions on these varieties are, however, of interest in academic studies, particularly with reference to the origin of new races. The reactions on "Belar" and "Sunrise", since they are grown in field areas, become more pertinent from the plant breeding viewpoint. It is of interest to observe that the two "side"-oat varieties belonging to *A. sativa orientalis*, "Green Mountain" and "White Tartar", react differentially to certain races, showing that varieties within this subspecies possess different genotypes with regard to crown rust reaction. In no instance have varieties belonging to the 7-chromosome species, *A. strigosa*, proved susceptible to crown rust, so that under Australian conditions they may prove of value in interspecific hybridization for transferring resistance to cultivated varieties in the 21-chromosome species. Many races attacking these varieties have been found in other countries, however, and there is no reason to suppose that they will remain resistant in this country in the future in view of the present variability exhibited by the fungus.

The new differential set obviously enables more satisfactory coordination in an oat breeding programme since the reaction on more varieties used as sources of crown rust resistance is shown. Race 286, apparently now of limited distribution, would, for example, have been assigned to the most prevalent, widespread and initially described race (race 6) on the former set, and the implications in the breeding programme not realized.

In any case it must be conceded that an arbitrary set of differentials, necessarily restricted in number, gives only a "rough" sorting of pathogenic entities into physiologic races. Profound differences in reaction type were observed by Waterhouse and Watson (1941) between two cultures of *P. graminis tritici* determined to be race 34 on the standard differential wheat stem rust set, one culture from the U.S.A. and the other from Australia, when additional varieties were added to the set. The recognition of this fact makes it obvious that the same sources of resistance to what are described as similar races may not be equally effective in two different centres. The use of a differential set permits only valid comparison on the varieties within that set without additional implications. Sources of resistance used by plant breeders should always be included for testing with local collections. It is agreed that the use of extra varieties will often sort apparently similar races into distinct biotypes, recognized as a lower category in designation. With an additional variety or varieties, what are apparently identical "physiologic races" on the accepted set of differential varieties can frequently be differentiated into further categories, designated as "biotypes" of that particular race. The same term is used in a different sense for a collection which consistently gives a minor variation on a differential variety from the reaction which is regarded as characteristic for the race. There is no guarantee that the term "biotype" is used in a strict genetic sense in these cases, but biotypes (of a race within a particular geographical region) may be regarded in general as similar until their reactions are shown to be different on a certain additional variety.

In any case, as Waterhouse (1952) points out, the distinction between a "physiologic race" and a "biotype" is an arbitrary one, and a satisfactory system for designating the rust entities has yet to be formulated. Waterhouse, in the present citation, suggests various schemes with comments. In the present instance, the writers consider that the use of suffixes "A" and "B", after the race number indicating resistance and susceptibility respectively, when the additional variety is clearly stated, is satisfactory, providing the reservations previously mentioned are kept in mind. It is considered to represent a compromise between a scheme attempting world-wide coordination on a standard and universal differential set and one where the sole emphasis is on sources of resistance utilized in plant breeding programmes in a particular country. Obviously the most accurate basis for race determinations is that where genes for resistance are used, rather than a selected set of varieties whose genotypes are not known for reaction. The genetics of the resistances in the differential varieties are being investigated at Sydney University with this ultimate objective in mind.

However, from the viewpoint of a comparison of race identification on the two differential sets, some attempt to link up investigations already carried out and races recognized on the former set with current investigations on the revised set seems desirable to preserve continuity in crown rust physiologic race investigations. For this reason both sets were, as indicated, sown for side-by-side comparisons, whilst the relative merits of race determinations on the revised set were being assessed.

Cultures described in Tables 1 and 3 are further shown in Table 4, where the reactions on varieties in both the former and new differential sets and the extra differential variety "Klein" are indicated. On this scheme 15 distinct rusts were clearly separable. In certain instances varieties outside the appropriate differential sets were incapable of further subdividing races into biotypes. For instance, varieties outside the former differential set failed to show that race 9 could be subdivided into biotypes. This culture was designated as race 240 on the new set and the former differential set likewise failed to reveal entities within this race. Races 1 and 6 were both shown to be composed of distinct biotypes when different collections of these races were tested on the new differentials and "Klein"; in this connection the varieties "Landhafer", "Ukraine" and "Klein" acted as extra differential varieties. Race 1 was shown to comprise two biotypes, one attacking "Ukraine"; to the second, "Ukraine" was resistant. Race 6 was shown to be composed of four biotypes. In this instance the reactions on the three varieties mentioned above outside the differential series were needed to designate these biotypes. Three of these biotypes gave a resistant reaction on "Landhafer"; to two of these, "Ukraine" was resistant and these two were finally separable by their differential reaction on "Klein".

Since, as previously indicated, the cultures were designated by only eight races on the new differential race numbers, it is apparent that varieties in the former differential set were in more instances capable of sorting these new races into biotypes than was the situation in the reciprocal direction. Biotypes were not distinguishable within races 240, 259 and 286. The remaining five were constituted of two or more biotypes. The varieties in these instances serving the function of extra differential varieties were "Ruakura", "Green Russian", "Hawkeye", "Green Mountain" and "Klein". In the case of race 237 three extra differential varieties were needed for biotype separations.

It is recognized in some instances that varieties previously referred to could have been replaced by others to serve the same purpose in biotype separation. For example, "Santa Fe" could have equally well separated race 6 into biotypes as did "Landhafer". If these two varieties have identical genotypes to Australian rusts, then they obviously serve equally well. On the other hand, if the genes for resistance are not identical, there is the possibility of further separating biotypes by the inclusion of the two varieties.

Further complications in biotype nomenclature become immediately apparent with the inclusion of differential reactions on more than one variety outside the particular differential set under consideration. Waterhouse (1952) pointed out certain aspects of these considerations and suggested that letters A and B could be again used for contrasting reactions of resistance and susceptibility on the second variety (the suffix BA or BB, for instance, following the race number) or the letters C and D used alone. In either case there is nothing to show which variety is used for the first separation or which for the second.

In the present instance the authors suggest the use of the letters A and B, C and D, E and F, etc., for contrasting reactions on the first, second and third, etc., extra-differential variety respectively. In this way there is no need to include reactions on extra-differential varieties unless pertinent, and if a key is appended to the race determination table the situation can be readily comprehended. Unless the situation is

TABLE 4.

Typical Reactions of Certain Physiologic Races of Puccinia coronata avenae *Expressed as Means of Rust Infections.*
Mean of Reactions on Differential Varieties.

Varieties Common to both New and Former Differential Sets.				Varieties in New Differential Set Only.						Varieties in Former Differential Set Only.									Variety Outside Differential Sets.	Physiologic Race No.		
Anthony.	Victoria.	Appler or Red Rustproof.	Bond.	Landhafer.	Santa Fe.	Ukraine.	Trispernia.	Bondvic.	Saia.	Ruakura.	Green Russian.	Hawkeye.	Sunrise.	Green Mountain.	White Tartar.	Sterisel.	Belar.	Glabrota.	Klein.	Former.	New.	Proposed International.
4	1^n	4	0;	;	;	;	1	1	;	4	4	4	4	4	4	4	4	0;	X^-	1 C	237 F	237 Anz 1
4	1^n	4	0;	;	;	4	1	1	;	4	4	4	4	4	4	4	4	0;	X^-	1 D	226 F	226 Anz 2
4	1^n	4	0;	;	;	;	1	1	;	1	4	4	4	4	4	4	4	0;	X^-	6 ACM	237 EHM	237 Anz 3
4	1^n	4	0;	;	;	4	1	1	;	1	4	4	4	4	4	4	4	0;	X^-	6 AD	226 E	226 Anz 1
4	1^n	4	0;	;	;	;	1	1	;	1	4	4	4	4	4	4	4	0;	3^+	6 ACN	237 EHN	237 Anz 4
4	1^n	4	0;	4	4	4	4	3	;	1	4	4	4	4	4	4	4	0;	X^-	6 B	286	286 Anz 1
;	1^n	4	0;	;	;	;	1	1	;	4	4	;	4	;	;	4	4	0;	X^-	7	238 K	238 Anz 1
4	1^n	2	0;	;	;	;	1	1	;	1	1	3	2	4	4	1	1	0;	$X^=$	9	240	240 Anz 1
;	1^n	4	0;	;	;	4	1	1	;	4	4	4	4	;	;	4	4	0;	X^-	20	230 J	230 Anz 2
;	1^n	4	0;	;	;	;	1	1	;	4	4	;	4	4	;	4	4	0;	X^-	40	238 L	238 Anz 2
;	1^n	4	0;	;	;	4	1	1	;	4	2	;	4	;	;	4	4	0;	X^-	46 (or 103)	230 I	230 Anz 1
4	1^n	4	4	;	;	4	1	1	;	4	4	3	4	3	3	4	4	0;	X^-	45	203 F	203 Anz 2
4	1^n	4	4	;	;	4	1	1	;	1	4	4	4	4	4	4	4	0;	X^-	57	203 E	203 Anz 1
4	1^n	4	0;	;	;	;	1	1	;	;	;	4	4	4	4	4	4	0;	X^-	102	237 EG	237 Anz 2
4	3	4	0;	;	;	4	1	1	;	1	4	4	4	4	4	4	4	0;	X^-	114	259	259 Anz 1

A–B Landhafer resistance vs. susceptibility.
C–D Ukraine resistance vs. susceptibility.
E–F Ruakara resistance vs. susceptibility.
G–H Green Russian resistance vs. susceptibility.
I–J Hawkeye resistance vs. susceptibility.
K–L Green Mountain resistance vs. susceptibility.
M–N Klein resistance vs. susceptibility.

clearly stated, confusion could readily occur in any scheme envisaged. For instance, an investigator in one country could assign certain designations to his entities, similar to those used elsewhere, where different extra-differential varieties had been employed. This further emphasizes the need for a central authority on a world basis to control and standardize physiological race studies on pathogenic organisms. Environmental modifications have, in addition to the problem herein discussed, been referred to previously; besides, there is always the possibility of genetic differences between stocks employed by different investigators.

Using the scheme suggested, race 6 was clearly divisible into four biotypic entities, viz., B, ACM, ACN and AD. Since the first biotype is clearly set apart by its susceptible reactions on "Landhafer", there appears little need to record reactions on the other extra-differentials—in this case "Ukraine" and "Klein". Likewise the fourth and last entity is shown to be distinct by its susceptibility on "Ukraine" in contrast to the second and third, and reactions on "Klein", whilst of importance in plant breeding, are not necessary in defining this biotype. The reaction on "Klein" can be readily determined by reference to a table of complete reactions. This variety is, however, necessary to categorize the second and third biotypes of race 6. Letters to designate seven contrasting reactions are indicated in Table 4.

Any procedure which enlarges the group of differential varieties increases the work involved, and some critical thought must be given to the extent to which extra-differential varieties can be added to race determination sets. This problem must be faced in the case of crown rust of oats. All varieties in the former differential set with the exception of Glabrota give contrasting reactions to one race or another, but they serve in many instances to illustrate variability in the organism without having any plant breeding significance. In any case there seems little need to include both varieties of *A. strigosa*—"Glabrota" and "Saia"; both are resistant to all Australian collections to which they have been tested. It has been regularly noted that "Glabrota" gives a lower reaction of a sharp "0;" type, whereas the "Saia" typical reaction is a ";" type with more pronounced necrosis associated with the reaction. This suggests that the factors for resistance are different in the two varieties, but this point must await genetic analysis.

Watson (1955), in race nomenclature, has used the suffix "Anz" after the race number, followed by numbers to indicate the number of biotypes of a particular race in the New Zealand and Australian geographical region. Since there is evidence that interchange of spore material can occur across the Tasman Sea, these two countries logically comprise one isolated geographical area. Such a scheme immediately indicates the location of a race under discussion, and implies that the reaction on varieties outside the differential set may show two races bearing the same number in different areas to be distinct. The present discussion is, however, somewhat different, in that a comparison is being attempted between the merits of the two differential sets. The rust designations under Watson's system with the new race scheme are shown in Table 4, and it is proposed from now on to adhere to this scheme to conform with overseas work, and in addition make the determinations of the utmost value to plant breeders. For brevity and international coordination this seems the best procedure to be followed.

Origin and Nature of Variability in the Crown Rust Organism.

In Australia, the alternate hosts, *Rhamnus* spp., obviously do not play an important part in the origin of new races. Species of this genus are restricted in distribution to Botanic Gardens. In England, the buckthorn, *R. catharticus* L., native to Northern Asia, is important in the production of new physiologic races (Griffiths, 1953). In the northern spring-oat areas of North America, including Canada, this species is important for the same reason (Welsh *et al.*, 1953). The uredospore stage does not overwinter, and infections are attributable to aecidiospores from the buckthorn, or uredospores which are windborne from the Southern United States area, where the rust overwinters on oats and grasses. Native species of buckthorn in North America, although they can be infected artificially by germinating teleutospores, are not considered of the same importance as the introduced *R. catharticus*, since they are usually not found near oat fields (Melhus *et al.*, 1952).

Attempts have been made to germinate teleutospores in this country, but the results in general have been disappointing. It has been found that spores formed under cooler temperature conditions which favour teleutospore germination in other rusts have been no more prone to break their dormancy, either when frozen in the refrigerator or exposed to winter conditions on the Tablelands. Germination after the initial freezing has not been encouraged by alternate thawing and freezing, although this procedure has been of value with other cereal rusts. Waterhouse (1952), however, reported the successful germination of teleutospores of race 6 and infection with production of spermogonia and aecidia on *R. catharticus* from which uredospore cultures were obtained on oats, thus completing the life cycle of the rust.

In the absence, in the first place, of the alternate host plant and also owing to the sporadic germination of teleutospores in any case, other means of reinfection of crops annually in Australia must be examined. It is apparent that oat plants, either self-sown ("volunteer") or belonging to the wild oat species, can be found infected at all seasons of the year. This particularly applies to the coastal areas; for instance, at Castle Hill oat plants can be always found carrying crown rust. By this means uredospores are considered to reinitiate new infection sites in cultivated crops. The culture of oats, with early sowing for grazing in the summer, also means that oat crops are grown for at least ten months of the year in many districts. It is generally considered also that spread by windborne uredospores from southern Queensland, where crops mature earlier, occurs in a southerly direction into New South Wales.

The role of grass species in the carry-over of *P. coronata avenae* is not completely known. Collections of *P. coronata* on *Lolium* spp., a rust which is particularly widespread and at times reaches epiphytotic proportions, have repeatedly failed to attack several varieties of oats normally susceptible to *P. coronata avenae*.

Murphy (1935) found certain wild-grass species outside the genus *Avena* susceptible to the six races of *P. coronata avenae* to which they were tested. *Dactylis glomerata* L. gave a variable reaction but was completely susceptible to one race. Although this grass is an important pasture plant in Australia, crown rust is uncommon on it, and it has only once been observed infected with *P. coronata* by the writers. Collections of *P. coronata* from *Holcus lanatus* L. and *Polypogon monspeliensis* (L.) Desf. have proved incapable of attacking oats; Waterhouse (1952), in addition, found a similar result with crown rust on *Agrostis avenacea* Gmel. Hence these must be regarded as different subspecies of *P. coronata*. However, much more remains to be done in determining the importance of native and introduced grasses in the carry-over of *P. coronata avenae* and in clarifying the taxonomic affinities of the subspecies of *P. coronata*.

Since the alternate host is for all practical purposes absent in Australia, new races appear to arise by mutation or by nuclear interchange in the dicaryotic phase. In studying the role of the latter phenomenon as a cause of rust variation, many workers have cultured dissimilar races of rusts together on fully susceptible varieties for many transfer generations without observable new recombinations of nuclei in the fungus. Waterhouse (1952), for example, cultured two such races of *P. graminis tritici* for twenty transfer generations without any new race being detected. He suggests, however, that particular associations of races may show affinities which lead to nuclear interchange. A recent abstract by Nelson and Wilcoxson (1954) is important in this aspect of variation. When uredospores of two or more races of *P. graminis tritici* were mixed on compatible and non-compatible wheat varieties and the resulting generation of spores transferred to resistant varieties, new biotypes were produced which differed from parent races in pathogenicity and/or colour. A particularly virulent biotype on the formerly highly resistant Khapli variety was, however, markedly unstable and after more than 30 generations was completely avirulent. Dissociation occurred on Khapli and apparently the virulent biotype was 3–4 nucleate compared with the normal avirulent binucleate condition. Such biotypes may, therefore, perhaps be considered as of no great importance in nature.

If hyphal anastomoses are of importance in the production of new biotypes or races, then the crown rust organism is offered many opportunities for this to occur in nature. Besides recombination which may result from haploid nuclear interchange in a pure culture of a single genetically heterozygous race, mixtures of races in a single collection on the one oat leaf are quite common and allow possible recombination between different races. Waterhouse (1952) commented on the prevalence of mixtures in collections studied, and some features of findings in present studies in this connection have already been presented, although the results during the past two years are not as yet completed for statistical compilations. With regard to the present aspect, it is pertinent to record that differential varieties such as "Ruakura", "Green Russian", "Hawkeye", and "Anthony" have given, quite often, a mixture of susceptible and resistant reactions on the one leaf, from which particular races have finally sorted out.

In view of the entirely hypothetical role which can be ascribed to vegetative recombination, mutation is the most logical phenomenon to explain the variability encountered in the crown rust organism. The evidence for this, whilst circumstantial, is suggestive. One would expect mutational processes to encompass successively single sources of resistance. Watson and Singh (1952) have pointed out the probable occurrence of stepwise mutations in the case of stem rust of wheat under Australian conditions. This is similarly exemplified in the case of race 114, which differs from race 6 in the present studies solely in its ability to attack "Victoria". Further, since race 6 is the most prevalent Australian race, from race survey studies one would expect a genetical change to be more likely to occur in this race and be subsequently detected. There is no reason to suspect that such mutations have not occurred before. In this instance the variety "Vicland" has obviously produced a "screening effect" which favours the new type. Reference to the physiologic race tables accompanying this paper show many other instances of races differing solely in reaction on one variety. In the case of mutations affecting varieties whose genotypes have been of no importance in economic breeding programmes, there is, of course, no such selective advantage. In these cases it may be that mutant types are better competitors on uniformly susceptible varieties. Competition studies in this respect have been reported by Watson (1942) and Watson and Singh (1952). The last-named reported that newer types originating, presumably, from mutation, with a wider host range, were in general poor competitors. This further suggests that similar mutation may have occurred before but failed to be maintained owing to competition. In the case of varying reactions exhibited on "Ruakura", for example, particular environmental conditions previously may have favoured in competition the new types capable of attacking it, in spite of the absence of a "screening effect", since this variety is of no importance economically. At the present time, however, environmental conditions may enable both types to exist together, apparently even on the one plant in certain instances, without a strong competitive effect. One final observation on these aspects is that mutations for avirulence could, of course, occur as well; they would be readily apparent since avirulence is dominant in general in other rust organisms studied genetically. It is feasible that mutations for pathogenicity may also have other physiological effects on the fungus, or that physiological effects may be due to mutations which produce no associated observable pathogenic changes. An analysis of the biotic factors concerned in competition trends would be of great interest; in the case of race 34 of wheat stem rust which rapidly replaced previously existing races in Australia (Waterhouse, 1929), Waterhouse (1939) suggested that the predominance of this race was explicable on two bases. Firstly it had a wider host range than the other Australian races, and, secondly, new crops of uredospores were produced more rapidly, enabling reinfection to occur earlier.

It is difficult in the laboratory to simulate the role nature can play on such a large scale in the field. Attempts are being made to produce mutations by irradiating the fungus, but the amount of material which can be handled in this way is limited, and may not approach in effect the significance of much lower mutation rate under natural conditions. Likewise anastomosis producing nuclear recombination is obviously offered larger opportunities over field areas to produce pathogenic changes.

Obviously the phenomena responsible for variability within the fungus will be better understood when the genetics of the pathogen have received further study. Such considerations as the dominance relationships of virulence *versus* avirulence, and the number of factors for pathogenicity in each case, are extremely important in discussions on mutation phenomena. Similarly the genetics of host plant resistance is important in such considerations, and this is a major part of the work being carried out at Sydney University at present.

There appears little evidence to support the hypothesis of adaptation by the rust to previously semi-resistant varieties. This hypothesis is based on the possibility that a race can adapt itself for full susceptibility to the environment imposed by its growth on a partially resistant variety.

Aspects Associated with Breeding for Resistance.

The advent of a race capable of attacking the variety "Victoria" and the susceptibility of varieties deriving their resistance from this source to Helminthosporium blight has made it of doubtful value as a parent in breeding for crown rust resistance under Australian conditions. This is particularly so in view of the wide distribution of this rust race, as revealed in the current survey and the seed-borne nature of Helminthosporium blight.

"Bond" likewise is suspect as a parent in breeding as it is susceptible to certain races. In this case the races do not appear to be widespread but apparently still persist annually in small amounts. Since the Queensland variety "Bovah" has "Bond" and "Victoria" as sources of resistance, it will be of the utmost importance to follow its behaviour in field areas. To date it has proved resistant to collections to which it has been tested. Certain overseas races shown on the key for identification attack both "Bond" and "Victoria". Griffiths (1953) also reports such a race.

Whilst race 286 is of limited distribution at the present time, it has extremely serious repercussions on any projected breeding programme. It attacks the varieties "Landhafer", "Trispernia", "Santa Fe" and "Ukraine", which have been specifically recommended and introduced as newer sources of resistance. The uniform susceptibility of these four varieties would indicate that they possess similar genotypes to Australian races to which they are resistant, or at least to the race from which 286 arose, presumably by mutation. However, the evidence from genetical studies indicates that this is unlikely. Local studies as yet incomplete (Baker and Upadhyaya, 1954) indicate that "Santa Fe", "Trispernia", and "Ukraine" have factors for resistance which are either closely linked or allelic, but that the single gene in "Landhafer" is different and independent genetically. These in general are the findings of Finkner (1954), except that his work suggests that in the case of the first three varieties two factors are operative in certain instances when race 57 is used. A differential reaction is shown by these varieties to certain overseas races, indicating that the factors for resistance are different in these cases. Presumably, therefore, race 286 differs from other races in possessing at least two new pathgenes if there is a gene-for-gene relationship between resistance in the host and virulence in the pathogen as shown by Flor (1954) to be the case in flax rust. It is difficult on a genetic basis to explain the moderate susceptibility of "Bondvic" to this race; however, Dr. M. D. Simons (personal communication) indicates that North American workers also have not been able to explain the behaviour of this variety on what might be expected from its parentage.

The variety "Klein 69B" is of doubtful merit as a source of resistance in view of its occasional susceptibility to biotypes in New South Wales and almost universal susceptibility in the field in Queensland, where rusts capable of attacking it seem to be more widespread.

The problems in breeding for crown rust resistance in oats are in a general way similar to those in breeding for resistance to other cereal rusts. In the case of wheat stem rust in Australia, the need for genetic diversity in sources of resistance has become obvious, as commercial varieties having a common source of resistance have simultaneously become susceptible to a new rust. Various suggestions to anticipate changes in the rust flora have been made in recent times. Watson (1949) suggested that prior preparation for the occurrence of new rusts could be undertaken by a backcross programme where single genetically different sources of resistance were added to appropriate commercial varieties. Borlaug (1954) advised the cultivation of a "composite variety" in this connection, made up of a mixture of backcrossed lines carrying different genotypes for resistance, the mixture being adjusted and altered according to the prevalence of particular rust races or biotypes. Watson and Singh (1952) outlined a scheme based on combined resistances where backcrossed lines are combined in one genotype to produce a derivative containing two genes, each of which controls resistance to all local rusts. Mutations affecting single loci would not become established, and the two sources of resistance would have to be affected simultaneously, which event would be expected to be highly unlikely on a probability concept. There is the possibility, however, that several host genes may be affected in the one mutation in the fungus, as shown by Newton and Johnson (1939) in the case of wheat stem rust. It has already been noted in this connection that in the present instance race 286 presumably arose by mutation and affected at least two genetically different sources of resistance. Hence combined resistances in certain cases may be of hypothetical value only. However, this method appears to offer the best means of breeding for resistance at the present time, provided the resistances are chosen with care, and no varieties having either single source of resistance are released to facilitate the step-by-step increase in virulence range.

Two other possibilities may be mentioned of value in breeding for resistance to crown rust. One is the transference by wide crossing to incorporate resistance from other species, such as *A. strigosa* (n = 7), varieties of which have been found resistant to all Australian isolates. Successful hybrids have been made by the authors between cultivated varieties (n = 21) and *A. barbata* (n = 14); such hybrids were highly sterile, and it is also probable that hybrids between *A. strigosa* and cultivated varieties are more difficult to accomplish. In any case, as previously noted, American races are capable of attacking this species and such interspecific hybridization may alone increase the range of genetic diversity and confer no permanent resistance in itself under Australian conditions.

The second point is the recent report by Browning and Frey (1954) on the production of stem rust resistant oat lines from irradiated seed of a rust susceptible variety. Certain strains were produced in the fifth generation following irradiation, which were resistant to more than one race and were agronomically desirable. Since only four hundred seeds were originally treated, this procedure may be of practical value in breeding for crown rust resistance.

Discussion and Conclusions.

Results of physiologic race studies herein presented indicate a great range of variability in pathogenicity in the crown rust fungus, presumably owing to step-wise mutation for increasing virulence. Causes of variability in the field are indicated as difficult of simulation under experimental conditions in the laboratory. It is obvious that more knowledge is needed on the genetics of the pathogen and of the host plant to secure fundamental information on the cause and possible range of variation in pathogenicity. To facilitate studies on the former aspect, problems associated with sporadic germination of teleutospores of Australian races are urgently in need of investigation. It is possible that in the absence of any role on the alternate hosts, Australian rusts may have lost the ability for ready teleutospore germination, but Waterhouse's results with other cereal rusts, and even *P. coronata avenae* itself, do not confirm this. Perhaps freezing to lower temperatures of –5° C. may encourage germination, and this possibility is being investigated. The fact that crown rust occurs on volunteer and wild species of *Avena* means that teleutospores can be collected over a wide seasonal range but no particular season for formation seems to result in improved germination. As suggested by Waterhouse (1952), different races may vary in ability for teleutospore germination. The genetics of host plant resistance is being investigated in great detail, on the other hand, and the results will shortly be presented to clarify the Australian situation. However, much more remains to be done before the host-pathogen genetic relationships are established on a basis comparable to that in flax rust, where Flor (1946, 1950) has established fundamental relationships in this connection.

The situation as regards the future in breeding for resistance is not particularly straightforward. Combined resistances before races of wide pathogenicity become established in the field seem to offer most promise. Genes from interspecific hybridization may increase genetic diversity in this respect. If results similar to those reported for stem rusts in oats can be obtained in the case of crown rust, irradiation to produce resistance in desirably agronomic varieties should not be neglected.

Sampling to indicate the distribution of races and biotypes in space and time needs to be intensified. Owing to limits on time and available assistance, some modification of the former differential oat crown rust set seems desirable to make the surveys of most use to plant breeders. It seems desirable to conform to the system of race nomenclature followed by North American workers, since their objectives are designed for results to be of utmost assistance in breeding programmes. At the same time certain varieties such as "Klein" might be added to separate Australian biotypes in view of their importance in the field; furthermore, varieties such as "Ruakura" which have served readily to separate Australian races on the former set might well be retained. As the amount of work which can be undertaken is limited, efforts should be directed to testing a larger number of collections on critical differentials rather than fewer on extra varieties of no breeding significance. The inclusion of a limited number of varieties from the former differential set would enable a certain amount of continuity to be maintained with previous local investigations; new race numbers would, at the same time, be in line with the central coordinating authorities in the U.S.A. and local biotypes could be indicated appropriately.

The growing of selected varieties in regions where crown rust is of importance would be of value in anticipating changes in pathogenicity in the field. Race 286, for instance, was detected by critical observation of a single row of the variety "Trispernia" at Castle Hill Research Station. Except for this instance, its presence would have remained undetected locally.

In view of minor modifications in reaction type produced by environmental influences, attempts to separate categories on anything more than a broad resistance and susceptible basis is considered to seek too much refinement unless reactions are compared with strictly comparable conditions by one central authority. The use of accurately controlled light chambers reduces such modification and enables determinations to be carried out when glasshouse conditions are unsuitable.

Stakman (1954) summarizes the position in regard to breeding for resistance to wheat stem rust thus: "Basic researches obviously are needed to determine the genetic potentialities for virulence in rust." In the case of crown rust of oats about which less is known, the need is obviously more paramount.

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NEW INFORMATION ON THE CORROBOREE FROG (*PSEUDOPHRYNE CORROBOREE* MOORE).

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[Read 26th October, 1955.]

Synopsis.

The original short taxonomic description of *Pseudophryne corroboree* was based on a single male spirit specimen in the collection of the Australian Museum, Sydney.

Through acquiring a large series of living specimens of this hitherto extremely rare frog, the author has been able to provide new information on the colour in life, on structure, habits in captivity, breeding habits, and on the egg and tadpole stages.

A correction has been made as to the type locality, which is in New South Wales, and not in Victoria as stated by Moore.

Historical.

Pseudophryne corroboree, the most brilliantly coloured species of the cryptozoic genus *Pseudophryne*, was first described by Moore (1953). Apart from being so outstandingly different in colour pattern from other members of the genus, the circumstances surrounding its discovery, and subsequent relevant events, are so decidedly unusual that they justify being put on record.

Moore (*loc. cit.*) "discovered" the type specimen (No. R13103), a male, in the collection of the Australian Museum, Sydney, New South Wales. The type locality, Towong Hill Station, near Corryong, Victoria, lies mainly on river flat country on the Victorian side of the upper reaches of the River Murray. It lies about 25 miles northwest of Mt. Kosciusko, and the height above sea-level is nine hundred feet. As will be shown later, this reported type locality is erroneous. The true locality is in New South Wales.

The type specimen was received by the Australian Museum in February, 1947, but, although it was obviously new, the Museum herpetologist, Mr. J. R. Kinghorn, felt that further specimens should be secured before a description could be undertaken. These were not forthcoming, and the frog remained undescribed until 1953, when it came under the notice of Dr. J. A. Moore, a visiting Fulbright scholar. Moore felt that in this instance he was justified in erecting a new species on a single specimen. Even allowing for the inevitable fading consequent upon a six-year sojourn in alcohol, the dorsal pattern with its broad stripes of black and pale yellow was still so strikingly different from that of any other known *Pseudophryne* (see figure in Moore, 1953) that he had no hesitation in making a new species. Apart from this single type specimen, other examples had been seen by the finder, Mr. Ossie Rixon, of Towong Hill Station. In a letter to Mr. J. R. Kinghorn he says: "They are rare but you do see them, generally about cattle pads."

During the Congress of the Australian and New Zealand Association for the Advancement of Science which was held in Canberra, A.C.T., Australia, in January, 1954, specimens of *P. corroboree* were found in sphagnum country in the upper regions of Mount Gingera (height 6092 ft.) near Canberra, which lies within the State of New South Wales. In this instance, the finder was the small son of Dr. M. J. D. White. The frogs were taken some distance below the summit, in boggy country, and were under logs and other debris. One specimen was sent to Moore who, in the meantime, had returned to his University at Columbia, N.Y. That brought the total number of known specimens in the possession of museums up to two.

Three days after this Gingera discovery, the author was presented with five living specimens of *P. corroboree* by Dr. A. Gunzburger, Engineering Geologist to the Snowy Mts. Hydroelectric Authority. These five came from an area between Island Bend (4000 ft.) and Smiggin Hole (5600 ft.) in the Snowy Mts. They were tracked down mainly by their call, and taken from burrows near a watercourse.

The acquisition of these five specimens marked the end of a long search, primarily instigated by Mr. D. G. Moye of the Hydroelectric Authority. Mr. Moye had seen Moore's paper in these PROCEEDINGS, and realized that the apparently rare *P. corroboree* actually occurred in some numbers in the Snowy area. They frequently came to light during bulldozing operations.

To the best of the present writer's knowledge, the total number of known specimens of *P. corroboree*, up till December, 1954, was seven, viz., the original type in the Australian Museum, Sydney, one at Columbia University, N.Y., U.S.A., and the author's five. To these, though, must be added an eighth, which was collected on Mt. Gingera, and sent to Mr. A. R. Main of the University of Western Australia at Perth.

In January, 1955, Prof. C. W. Emmens, of the Department of Veterinary Physiology, Sydney University, informed the author that a Sydney medico, Dr. A. E. Fraser Chaffer, had collected a hundred specimens of *P. corroboree* in yet another locality—near Alpine Hut, in the Mt. Kosciusko area. This happened in late December, 1954, and early January, 1955. The height above sea-level in this locality is about six thousand feet. The terrain here is decidedly boggy, and the frogs were taken from burrows, some of which were as deep as ten inches, in rotting vegetation beneath the surface growth of sphagnum moss.

Most of the first batch of about fifty, which were brought back to the hut, were eaten by a black snake. Fifty or so more were therefore collected, this operation requiring little more than half an hour. Many hundreds of the frogs could have been taken with ease.

Dr. Chaffer returned to the Alpine Hut area at Easter (April), 1955, but a vigorous search, extending over several days, yielded only four undersized examples of *P. corroboree*. The hundreds which had been there three months previously had disappeared. Their exact whereabouts is not known. The earlier specimens had all been taken in the vicinity of a tongue of land extending down from the main range of mountains, and surrounded on three sides by water. The frogs must have either burrowed down very deeply indeed in anticipation of the coming snows that will bury them for several months, or else they have left their marshy summer habitat for higher ground. In the course of both of his visits, Dr. Chaffer collected developmental stages. Further mention of these is made below.

He informs me that he has been aware of the existence of the corroboree frog for more than four and a half years, i.e., something like two and a half years *before* the appearance of Moore's original description. He saw his first specimen at Ryrie's Parlor, a little to the west of Alpine Hut, in December, 1951. It was not until November, 1954, that he learned of the great scientific interest associated with *Pseudophryne corroboree*. He points out that the true locality of the type specimen is not Towong Hill Station, Victoria, as stated in Moore's paper. The real locality is on one of the snow leases of this property—Round Mountain, sometimes known as Lett's Trig Station. This is on the upper reaches of the Tumut River in New South Wales. It lies 30–35 miles north-east of Towong Hill Station, and the height above sea-level is 5758 ft. The excerpt from the letter written to Mr. J. R. Kinghorn of the Australian Museum by the station owner, Mr. T. W. Mitchell (quoted by Moore, 1953), says that the type specimen "was found at the foot of a fence post at the foot of Round Mountain". The height, even at this reduced level, would be well above the snowline.

Another locality where specimens had been seen, but not collected, by station personnel, was at Fifteen Mile, which also lies in New South Wales, and is part of the old Kiandra goldmining field, 5–6 miles north of Round Mountain, and 4500–5000 ft. above sea-level.

It is thus apparent that Moore's paper should be restyled "A New Species of *Pseudophryne* from New South Wales", and the type locality changed from Towong Hill Station, Victoria, to Round Mountain, New South Wales.

What at first appeared to be a very rare new frog species turns out to be relatively common within the confines of its montane habitat.

It should be noted here that none of the local inhabitants who were shown the corroboree frog by Dr. Chaffer could say that they had seen one before. This is perhaps explained by the frog's burrowing habits which keep it out of sight most of the time.

Now that the matter of type locality has been cleared up, *P. corroboree* emerges as a cryptozoic species with a range restricted to high altitudes (4500 ft. and up) which are under snow for several months of the year.

An interesting problem that awaits further illumination is whether this species will be found in other elevated localities in New South Wales where similar environmental conditions (especially sphagnum bogs) are to be met with.

Colour and Other Structural Features.

a. Colour.

With the acquisition of living specimens, the author was able to make some observations of the true colours. The pattern of bold longitudinally disposed dorsal stripes shown in Moore's illustration (*loc. cit.*) is quite representative, although there are minor variations. The author has four of the original five living specimens presented to him by Dr. Gunzburger in January, 1954. The fifth specimen died unaccountably in September, 1954, and now reposes in the British Museum. In addition the author has eleven preserved specimens (*ex* Chaffer). These were given to him alive by Prof. C. W. Emmens, but died a few weeks later from an infection. The series is too small to give an adequate idea of colour variation or, more particularly, pattern variation, but it is large enough to allow some amplification of the description of the spirit specimen which is the type.

The black of the latter is, in life, a very shiny black, and the pale yellow a shiny bright yellow or yellow-orange. The dark blotches on the limbs and on the ventral surface are also shiny black in the living animal, but of the pale blotches some are yellow, some are mixed yellow and pale blue (each colour clearly defined), some are uniformly pale blue, and others are white.

For any given individual there are three typical combinations of black and pale areas, respectively, on the ventral surface, viz., black and yellow, black, yellow and pale blue, or black and white. The latter combination is very similar to the characteristic marbled pattern seen on the ventral surface of the related species, *P. australis* and *P. bibroni*.

It has been noticed that during the first month of winter of this year (1955) the pale blue blotches of the four surviving *P. corroboree* in the author's possession have turned white. These animals have been in captivity for more than eighteen months.

b. Body proportions.

Body measurements have been made on twelve preserved specimens. One of these is a post-metamorphic juvenile, and the others are sexually mature. All come from the Alpine Hut region near Mt. Kosciusko.

These measurements are given in Table 1, which also includes Moore's figures from the type specimen.

In four of the eleven adults, the fourth toe reached beyond the snout, in four of them it reached the snout, and in three it only reached as far as the anterior margin of the eye. In the juvenile specimen it reached beyond the snout. In one of the adults, the tibiotarsal articulation, in the adpressed limb, reached as far as the anterior edge of the arm. In eight of them it reached the armpit, while in two female specimens (Nos.

1 and 2) it fell notably short of the armpit. In one female (No. 1) it fell short by one-third of the distance from vent to armpit. In the juvenile it reached midway between the armpit and the eye.

c. Thigh muscles.

Noble (1922) has shown that the relationship of the distal tendon of the semitendinosus muscle to that of the combined gracilis major and minor is of considerable assistance in elucidating anuran affinities. He finds that there are two extremes here. In his "ranid" type, the distal tendon of the semitendinosus lies dorsal to the graciles, while in the "bufonid" type the tendon lies ventral to the latter.

TABLE 1.

Specimens ..	Type	1	2	3	4	5	6	7	8	9	10	11	12
Body length in mm.	24	31	27	25	25	25	26	25	25	25	26	26	8·9
Sex	M.	F.	F.	M.	M.	M.	M.	M.	M.	M.	M.	F.	Juv.
Length of tibia ..	7·9	8·5	8·7	9·2	9·2	8·7	7·5	8·3	8·7	7·5	7·5	8·7	1·9
Width of head at posterior end of jaws	7·0	9·7	8·3	8·3	8·3	7·7	7·5	7·0	8·3	8·0	8·5	8·5	3·3
Tip of snout to centre of nares	1·1	1·7	1·0	1·3	1·3	1·3	1·2	1·3	1·5	1·5	1·2	1·3	0·3
Centre of nares to anterior corner of eye	1·7	2·2	2·0	1·8	1·8	1·8	1·8	1·7	1·8	2·0	1·8	2·0	0·6
Antero - posterior eye measurement	2·2	2·5	2·3	2·0	2·5	2·5	2·3	2·5	2·5	2·0	2·0	2·0	1·2

F.=female. M.=male. Juv.=juvenile (post-metamorphic).

Parker (1940, p. 9) gives a table which shows that Australian leptodactylids can be divided into four groups with respect to this relationship. The two leptodactylid subfamilies, the Cycloraninae and the Myobatrachinae, show a complete gradation from one extreme to the other, but this gradation is in four definite steps. The bufonid type is found only in the Cycloraninae, and the ranid type in the Myobatrachinae. These are the extremes, but there are two intermediate conditions which presumably represent stages in the migration of the semitendinosus tendon from the superficial (bufonid) position to the deep and more specialized ranid one.

Thus in *Limnodynastes ornatus*, *Lechriodus melanopyga*, *L. platyceps*, *L. fletcheri*, and in *Adelotus brevis* (all Cycloraninae), as well as in *Uperoleia marmorata*, *Crinia georgiana*, *C. signifera*, *C. laevis*, and *C. tasmaniensis* (Myobatrachinae) the distal tendon of the semitendinosus perforates the gracilis complex. These species constitute Parker's Group II.

His Group III contains *Pseudophryne australis*, *P. bibroni*, and *P. coriacea*, as well as *Glauertia orientalis*. In these species, the distal tendon of the semitendinosus perforates the *ligamentous head* of the graciles. The members of his Group IV all show the specialized ranid condition, where the tendon of the semitendinosus muscle passes dorsal to the graciles. The species in this group are *Glauertia russelli*, *Metacrinia nichollsi*, and *Myobatrachus gouldii*.

The tendon relationships in *Pseudophryne corroboree* turn out to be particularly interesting, but, before going into details of these, attention is directed to the fact that, although tendon relationships are constant for any given species, not all species of the same genus necessarily belong to the same group. Compare for instance *Glauertia orientalis* (Group III) and *G. russelli* (Group IV).

In *Pseudophryne corroboree*, the gracilis major and gracilis minor muscles share a common distal tendon which is considerably narrower than the rather broad distal end